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BOREAS RSS-14 Level 1a GOES-7 Visible, IR, and Water Vapor Images

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Summary

The BOREAS RSS-14 team collected and processed GOES-7 and -8 images of the BOREAS region as part of its effort to characterize the incoming, reflected, and emitted radiation at regional scales. The level-1a BOREAS GOES-7 image data were collected by RSS-14 personnel at FSU and processed to level-1a products by BORIS personnel. The data cover the period of 01-Jan-1994 through 08-Jul-1995 with partial to complete coverage on the majority of the days. The data include three bands with eight-bit pixel values. No major problems with the data have been identified.

Note: due to the large size of the images, the level-1a GOES-7 data are not contained on the BOREAS CD-ROM set. An inventory listing file is supplied on the CD-ROM to inform users of what data were collected. The level-1a GOES-7 image data are available from the Earth Observing System Data and Information System (EOSDIS) Oak Ridge National Laboratory (ORNL) Distributed Active Archive Center (DAAC). See sections 15 and 16 for more information.

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1. Data Set Overview

1.1 Data Set Identification

BOREAS RSS-14 Level-1a GOES-7 Visible, Infrared, and Water Vapor Images

1.2 Data Set Introduction

The BOReal Ecosystem-Atmosphere Study (BOREAS) Staff Science effort covered those activities that were BOREAS community-level activities or required uniform data collection procedures across sites and time. These activities included processing the level-1 Geostationary Operational Environmental Satellite (GOES)-7 images acquired by Dr. Eric Smith of Florida State University

(FSU) into level-1a products.

1.3 Objective/Purpose

For BOREAS, the level-1a GOES-7 imagery, along with the other remotely sensed images, was collected in order to provide spatially extensive information over the primary study areas at varying spatial scales. The primary objective for the GOES-7 images in 1994 was to collect visible, infrared (IR), and water vapor channel data covering the BOREAS region at a sufficiently high temporal frequency for subsequent use in analyzing weather events and deriving temporal surface radiation parameters and patterns that existed during the Focused and Intensive Field Campaigns (FFCs and IFCs). The transition and shifting of satellites from GOES-7 to GOES-8 in 1995 enabled good quality images to be acquired over the BOREAS region four times per day from January to June, giving a reasonable monitoring data set.

1.4 Summary of Parameters

The level-1a GOES-7 data from 1994 and 1995 in the BOREAS Information System (BORIS) contain the following parameters: image header and summary information; central geographic position; digital counts for half-hourly visible and IR images and digital counts for hourly water vapor images.

1.5 Discussion

Dr. Smith provided BORIS with the level-1 GOES-7 images that were used to create the level-1a products. BORIS staff processed the level-1a GOES-7 images by:

- summarizing and extracting header information from the level-1 GOES-7 images and placing it in an American Standard Code for Information Interchange (ASCII) file on disk,
- reviewing the header file information for potential errors,
- working with FSU personnel to remove erroneous files detected in step 2,
- repackaging/reformatting the image data for a given day,
- writing the reformatted data files to tape, and 6) loading the online data base with needed information.

1.6 Related Data Sets

BOREAS RSS-14 Level-1 GOES-7 Images from 1994 and 1995
BOREAS RSS-14 Level-2 GOES-7 Shortwave Radiation Images
BOREAS RSS-14 Level-3 Gridded Radiometer and Satellite Radiation Images
BOREAS RSS-14 Level-1 GOES-8 Images from 1995 and 1996
BOREAS RSS-14 Level-1a GOES-8 Images from 1995 and 1996

2. Investigator(s)

2.1 Investigator(s) Name and Title

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2.2 Title of Investigation

GOES Imagery for the BOREAS Experimental Areas

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3. Theory of Measurements

The GOES mission is to provide the nearly continuous, repetitive observations that are needed to predict, detect, and track severe weather. GOES spacecraft are equipped to observe and measure cloud cover, surface conditions, snow and ice cover, surface temperatures, and the vertical distributions of atmospheric temperature and humidity. They are also instrumented to measure solar X-rays and other energetics, collect and relay environmental data from platforms, and broadcast instrument data and environmental information products to ground stations. The GOES system includes the satellite (with the GOES instrumentation and direct downlink data transmission capability); the National Environmental Satellite, Data and Information Service (NESDIS) facility at Wallops Island, VA; and the ground systems at NESDIS.

4. Equipment

4.1 Sensor/Instrument Description

The original GOES instrument was the Visible and Infrared Spin Scan Radiometer (VISSR), which was an outgrowth of the spin scan radiometer flown aboard several of the Applications Technology Satellite (ATS) series of the National Aeronautics and Space Administration (NASA) research satellites. The VISSR was first flown aboard Synchronous Meteorological Satellite (SMS)-1 and SMS-2 used by the National Oceanic and Atmospheric Administration (NOAA). GOES-1, -2, and -3 were operational satellites that flew the original VISSR instrument. GOES-4 through -7 were flown with a modified instrument package called the VISSR Atmospheric Sounder (VAS). A set of IR sensors was added to provide an atmospheric sounder capability.

The VAS instrument system is an expansion of the VISSR system with improved structural design and some additional capabilities. It consists of the same type of scanning system, a telescope with lighter weight optics made from beryllium instead of conventional materials (glass, steel), eight visible detectors (25 x 24 μm Instantaneous Field of View (IFOV)), and six IR detectors.

GOES-7 Channel	Wavelength, µm
1 (visible)	0.5-0.7
8 (IR)	11.17
10 (water vapor)	6.725

4.1.1 Collection Environment

The data were acquired using the FSU direct readout ground system located in Tallahassee, FL, starting on 01-Jan-1994 and continued through 08-Jul-1995. GOES-7 orbited Earth in a geostationary orbit at an altitude of 42,000 km.

4.1.2 Source/Platform

Launch and data-available dates for GOES-7 are:

Satellite	Launch Date	Data Range
GOES-7	26-Feb-1987	25-Mar-1987 to mid-1995

4.1.3 Source/Platform Mission Objectives

See Sections 1.3 and 3.

4.1.4 Key Variables

Reflected radiation Emitted radiation Water vapor

4.1.5 Principles of Operation

The VISSR instrument consists of a scanning system, telescope, and IR and visible sensors. The scanning system consists of a mirror that is stepped mechanically to provide north-to-south viewing, while the 100-rpm rotation of GOES provides west-to-east scanning. The mirror is stepped following each west-to-east scan. The mirror position is controlled by one of two optical encode wheels attached to the axis. Each step of the mirror causes a change of 192 µrad in the scan angle, representing a distance of 6.9 km near nadir. A sequence of 1,821 scans over 18.21 minutes is performed to provide a "full disk" view from just beyond the northern Earth horizon to just beyond the southern Earth horizon.

The scanning mirror reflects the received radiation into a 16-inch-diameter telescope. A fiber-optics bundle is used to couple the telescope to eight visible detectors (sensitive to the 0.54- to 0.70-micrometer band). The fiber-optics bundle is configured such that each of the eight VIS sensors has a 20 (W-E) x 25 (N-S) µrad field of view (FOV) on GOES-7. The sensors are arranged in a linear array oriented "north-south" (i.e., perpendicular to the scan direction), thus sweeping out eight parallel scan line paths as the satellite rotates. The FOV provides a ground resolution of 0.9 km (normally referred to as 1 km or 0.5 nautical mile). The system thus provides eight parallel visible data lines per west-to-east scan, covering the 6.9-km (normally referred to as 8 km or 4 miles) band scanned by each step of the scanning mirror. In addition, germanium relay lenses are used to pass received radiation to two mercury-cadmium-tellurium (HgCdTe) IR detectors by way of a 10.5- to 12.6-micrometer bandpass filter. The FOV of the IR detectors is 192 µrad (equal to the north-south scan step angle); thus, the IR sensors provide equivalent coverage to the eight visible sensors.

The output from the eight visible (VIS) detectors and from one of the two IR detectors (or an average of both IR detectors) is digitized onboard the satellite and transmitted to Earth in real time. The visible data are sampled every 2 microseconds, which yields visible samples spaced at increments of satellite rotation of 20.9 µrad (assuming a nominal satellite spin rate of 100 rpm), or a near-nadir spacing of 3.0 km. Since the IR detector FOV is 192 µrad, the IR data are therefore oversampled in the scan direction. The quantization of the IR data is 8 bits, and of the VIS 6 bits. The visible scanners are digitized with a square root digitizer for better signal-to-noise ratio. The oversampling of the IR data leads to the designation of the IR data as "4 x 2" IR data (4-mile resolution north-south, 2-mile resolution west-east). The full-resolution scan of all sensors in the mode produces about 226 MB of data per image.

4.1.6 Sensor/Instrument Measurement Geometry

When the VISSR/VAS is installed in the spacecraft, its optical axis becomes parallel to the spacecraft spin axis, which must be parallel to Earth's spin axis. The VAS optical axis is thus perpendicular to the direction of the Earth scene. The optically flat scan mirror of the VAS, placed at a 45-degree angle to the VAS optical axis, directs the Earth scene into the VAS. The spinning is accomplished by stepping the scan mirror from 40 degrees, representing the north polar extreme, to 50 degrees, representing the south polar extreme. An angle position encoder integral with the mirror stepping mechanism converts the position information to electrical signals, which are sent to aid in reassembly of the Earth scene. The 10 degrees of mirror motion (resulting in 20 degrees of optical angle due to doubling the optical angle at the mirror) is divided into 1,821 steps, each representing 192 μrad optically.

At the image plane, a relatively large FOV is available. Each detector element is dimensional to define the FOV that its signal is intended to represent. For example, the smallest IR field is 192 μrad defined by a square detector 0.00315 inches on each side. (At synchronous altitude, 192 μrad is equivalent to 5 miles along Earth's surface at the satellite's suborbital point.)

Two focal planes are used in the VAS. Visible spectrum signals are obtained at the principal focus. An optical fiber for each of the eight FOVs defines the field to be measured (25 x 24 μrad) and conveys the impinging light within that FOV to a photomultiplier tube, which converts the light intensity to a proportional electrical current. IR radiation must be sensed by solid-state detectors that are cooled to a low temperature to reduce their intrinsic electrical noise to a level below the electrical equivalent of the least intense radiation to be measured. This cooling is provided by a radiation cooler that radiates excess heat into space. Because of spacecraft design constraints, the cooler must be located away from the prime focal plane. The relay optics provide an appropriate location for an IR focusing mechanism and filter assembly out of the visible light path. The filter assembly contains an 11.2-cm disc, called a filter wheel, that houses 12 spectral-pass band filters. During each scan, one filter is placed in the IR path to acquire data in the desired spectral band. Any one of the filters can be positioned in the IR optical FOV within 350 milliseconds (i.e., during the time that the VAS telescope is not viewing Earth during a given spin). Filters are inserted in the IR path only and are used in the Multispectral Imaging (MSI) and sounding modes. While 38 channels are possible with the filter wheel detector combinations, only 13 bands can be transmitted.

The scanning schedule and the various modes of operation are uploaded to an electronics module in the satellite. The satellite includes an onboard controller that can itself be reprogrammed via the spacecraft command link.

4.1.7 Manufacturer of Sensor/Instrument

Hughes Santa Barbara Remote Sensing (SBRS) Goleta, CA

4.2 Calibration

The VISSR channels are calibrated in a vacuum environment at five instrument temperature plateaus. Some adjustments are made to standardize the bit content and start time of the stretched data scans.

Preflight Calibration

- Visible Channels: The visible channel calibration source is a quartz iodine lamp, the output of which is collimated and spectrally shaped using appropriate optical filters to create an output similar to the Sun over the spectral band of the VISSR visible channels. The output level of the calibration source is established by eight neutral density filters that provide a calibration range from 16% to 100% albedo. The absolute calibration accuracy of the VISSR visible channels is estimated to be +/- 10%.
- Thermal Channel: The VISSR thermal channels are calibrated at eight target scene temperatures between 180 and 315 K, using a temperature-controlled blackbody source. The estimated absolute calibration accuracy is +/- 1.5 °C, or +/- 1% of full scale, whichever is larger.

Inflight Calibration

- Visible Channels: Inflight calibration of the eight VISSR visible PMTs is accomplished by viewing the Sun through the complete visible channel optical train via a "side-looking," reduced-aperture collecting prism. The visible channel gains are adjusted in the ground station processing to equalize the eight scanners. This is done to remove stripping of the images. Other gain adjustments are made occasionally for image clarity. Absolute calibrations with the Sun viewer are not part of the GOES operating procedure. However, some research programs have produced limited calibrations for parts of the GOES data record.
- Thermal Channels: The inflight calibration of the VISSR thermal channels is accomplished by monitoring the temperature of a blackbody. This blackbody is activated by command and introduced into the optical path just ahead of the IR relay optical system. The space view by VISSR provides an approximately zero signal reference in the thermal bands that is used to establish the zero end of the measurement scale.

The level-1a GOES-7 images have not had any calibration applied. Information on calibration procedures can be found at http://haboob.giss.nasa.gov/isccp.html.

4.2.1 Specifications

```
IFOV
   Visible        25 x 24 µrad
   IR             192 x 192 µrad
RESOLUTION (subsatellite)
   Visible        0.9 km
   IR             6.9 km
ALTITUDE          42,000 km
GOES SPIN RATE    100 rpm
SCAN RATE         1,821 scans/min
SCAN RANGE        approx. 60N to 60S degrees latitude
SAMPLES/SCAN      3,822 IR and 15,288 visible samples per PMT
                  detector per Earth scan
```

GOES-7 for 1993 through November 1994 was stationed at approximately 0.0 degrees N, 112.57 degrees W. In November 1994, it was gradually moved westward so that by 23-Feb-1995, it was at approximately 0.0 degrees N, 136.1 degrees W.

4.2.1.1 Tolerance

Not available at this revision.

4.2.2 Frequency of Calibration

Calibration of the visible and IR channels is performed after every scan using internal calibrators that are part of the VAS and VISSR instrumentation. However, routine calibrations are not made on the visible sensor. The calibration procedures for calculating visible radiances and IR brightness temperatures from counts follows Rossow et al. (1992) and Rossow et al. (1995).

4.2.3 Other Calibration Information

It is pertinent to note that the IR values included in the VAS VISSR data stream are recalibrated values from NESDIS operations. No recalibration is performed on the normalized raw visible data. The Synchronous Data Buffer (SDB) uses a lookup table to replace the original IR data values transmitted from the satellite with recalibrated values that are intended to correspond to a predetermined data value versus temperature table. The lookup table is computed by NESDIS weekly, based on calibration parameters received from the instrument.

More information on calibration procedures can be found at http://haboob.giss.nasa.gov/isccp.html

5. Data Acquisition Methods

The BOREAS level-1 GOES-7 images used in the level-1a product creation were obtained by Dr. Eric Smith at FSU and supplied to BORIS. The data were acquired using the FSU direct readout ground system located in Tallahassee, FL, starting on 01-Jan-1994 and continued through 08-Jul-1995.

6. Observations

6.1 Data Notes

Not available at this revision.

6.2 Field Notes

Not applicable.

7. Data Description

7.1 Spatial Characteristics

7.1.1 Spatial Coverage

The VISSR scanning system consists of a mirror that is stepped mechanically to provide north-to-south viewing, while the rotation of GOES provides west-to-east scanning. The mirror is stepped following each west-to-east scan. A sequence of 1,821 scans over 18.21 minutes is performed to provide a "full disk" view from just beyond the northern Earth horizon to just beyond the southern Earth horizon.

Based on the level-1 GOES-7 images, the BOREAS level-1a GOES images essentially cover the entire 1,000-km x 1,000-km BOREAS region. This contains the Northern Study Area (NSA), the Southern Study Area (SSA), the transect region between the SSA and NSA, and some surrounding area.

Based on information contained in the reference latitude and longitude files for the visible, IR, and water vapor bands (see Section 8.2), the following values represent the nominal coverage of the various bands:

	Visible Latitude	Visible Longitude
Northwest	64.757°N	107.037°W
Northeast	65.911°N	87.120°W
Southwest	47.646°N	109.210°W
Southeast	47.916°N	98.087°W

	IR Latitude	IR Longitude
Northwest	64.807°N	107.045°W
Northeast	65.957°N	87.156°W
Southwest	47.758°N	109.212°W
Southeast	48.028°N	98.096°W

	Water Vapor Latitude	Water Vapor Longitude
Northwest	64.605°N	107.088°W
Northeast	65.728°N	87.410°W
Southwest	47.758°N	109.212°W
Southeast	48.028°N	98.096°W

The North American Datum of 1983 (NAD83) corner coordinates of the 1,000- x 1,000-km BOREAS region are:

	Latitude	Longitude
Northwest	59.97907°N	111.00000°W
Northeast	58.84379°N	93.50224°W
Southwest	51.00000°N	111.00000°W
Southeast	50.08913°N	96.96951°W

7.1.2 Spatial Coverage Map

Not available at this time.

7.1.3 Spatial Resolution

The spatial resolution of each pixel is dependent on the off-nadir scan angle of the sensor and increases from nadir to the scanning extremes. The satellite subpoint resolution of the various channels is:

	North/South	East/West
Visible	1 km	1 km
IR	8 km	4 km
Water Vapor	16 km	4 km

The spatial dimensions of each pixel can be calculated from the provided latitude and longitude coordinate information (see Section 8.2).

7.1.4 Projection

The BOREAS level-1a GOES-7 images are stored in the same GOES "perfect" projection as the level-1 images. The "perfect" projection indicates that the satellite movement between temporal acquisitions has been removed so that the images are aligned spatially. Detailed information about the projection is not currently available.

7.1.5 Grid Description

Not available at this revision.

7.2 Temporal Characteristics

7.2.1 Temporal Coverage

In 1994, the period of data acquisition was from 01-Jan-1994 through 31-Dec-1994. During this period, whole days of data are missing, leaving 348 days with partial or complete acquisitions. In 1995, the GOES-7 data were collected from 01-Jan-1995 to 08-Jul-1995. In July 1995, the data sequence was continued with data from GOES-8 (see BOREAS GOES-8 data sets).

7.2.2 Temporal Coverage Map

Not available at this time.

7.2.3 Temporal Resolution

During 1994, the visible and IR images were acquired on the hour and 30 minutes after the hour, 24 hours a day. The water vapor channel data are available only at the top of the hour. Partial to complete data are available on 348 out of the 365 days in 1994. Within a given day, some images may be missing. Where a level-1 image was missing at a particular time, a "fill" image containing all zeros was inserted in the level-1a data set.

The transition and shifting of satellites from GOES-7 to GOES-8 in 1995 enabled good quality images to be acquired over the BOREAS region a maximum of 12 times per day from January to July, giving a reasonable monitoring data set. After 08-Jul-1995, the GOES images were acquired from the GOES-8 satellite (see BOREAS GOES-8 data sets).

7.3 Data Characteristics

7.3.1 Parameter/Variable

The parameter contained in the image data files is: Digital Number (DN)

The parameters contained in the inventory listing file on the CD-ROM are:

```
        Column Name
------------------------------
SPATIAL_COVERAGE
DATE_OBS
START_TIME
END_TIME
PLATFORM
INSTRUMENT
NUM_BANDS
BAND_QUALITY
CLOUD_COVER
NUM_VIS_IMAGES
NUM_IR_IMAGES
NUM_WV_IMAGES
CRTFCN_CODE
```

7.3.2 Variable Description/Definition

For the image data files:

```
Digital Number (DN) - The quantized DN derived by the GOES-7 scanning system for
                      the respective channel.
```

The descriptions of the parameters contained in the inventory listing file on the CD-ROM are:

Column Name	Description
SPATIAL_COVERAGE	The general term used to denote the spatial area over which the data were collected.
DATE_OBS	The date on which the data were collected.
START_TIME	The starting Greenwich Mean Time (GMT) for the data collected.
END_TIME	The ending Greenwich Mean Time (GMT) for the data collected.
PLATFORM	The object (e.g., satellite, aircraft, tower, person) that supported the instrument.
INSTRUMENT	The name of the device used to make the measurements.

NUM_BANDS	The number of spectral bands in the data.
BAND_QUALITY	The data analyst's assessment of the quality of the spectral bands in the data.
CLOUD_COVER	The data analyst's assessment of the cloud cover that exists in the data.
NUM_VIS_IMAGES	The number of visible GOES-7 images that are contained in the image product.
NUM_IR_IMAGES	The number of GOES-7 infrared images that are contained in the image product.
NUM_WV_IMAGES	The number of GOES-7 water vapor images that are contained in the image product.
CRTFCN_CODE	The BOREAS certification level of the data. Examples are CPI (Checked by PI), CGR (Certified by Group), PRE (Preliminary), and CPI-??? (CPI but questionable).

7.3.3 Unit of Measurement

For the image data files: Digital Number (DN) - counts

The measurement units for the parameters contained in the inventory listing file on the CD-ROM are:

Column Name	Units
SPATIAL_COVERAGE	[none]
DATE_OBS	[DD-MON-YY]
START_TIME	[HHMM GMT]
END_TIME	[HHMM GMT]
PLATFORM	[none]
INSTRUMENT	[none]
NUM_BANDS	[counts]
BAND_QUALITY	[none]
CLOUD_COVER	[none]
NUM_VIS_IMAGES	[counts]
NUM_IR_IMAGES	[counts]
NUM_WV_IMAGES	[counts]
CRTFCN_CODE	[none]

7.3.4 Data Source

The level-1 GOES-7 image bands were collected by the VISSR instrument on the GOES-7 spacecraft. The raw data were received, processed and subset, and sent to BORIS by personnel within the Department of Meteorology at FSU. The sources of the parameter values contained in the inventory listing file on the CD-ROM are:

Column Name	Data Source
SPATIAL_COVERAGE	[Constant software parameter value]
DATE_OBS	[Level-1 GOES-7 header record]
START_TIME	[Constant software parameter value]
END_TIME	[Constant software parameter value]
PLATFORM	[Constant software parameter value]
INSTRUMENT	[Constant software parameter value]
NUM_BANDS	[Constant software parameter value]
BAND_QUALITY	[Constant software parameter value]
CLOUD_COVER	[Constant software parameter value]

```
NUM_VIS_IMAGES                  [Count from processing software]
NUM_IR_IMAGES                   [Count from processing software]
NUM_WV_IMAGES                   [Count from processing software]
CRTFCN_CODE                     [Constant data base value]
```

7.3.5 Data Range

The maximum range of DNs in each GOES image band is limited from 0 to 255 so that the values can be stored in a single 8-bit (1-byte) field. The following table gives information about the parameter values found in the inventory table on the CD-ROM.

Column Name	Minimum Data Value	Maximum Data Value	Missng Data Value	Unrel Data Value	Below Detect Limit	Data Not Cllctd
SPATIAL_COVERAGE	N/A	N/A	None	None	None	None
DATE_OBS	04-JAN-94	08-JUL-95	None	None	None	None
START_TIME	0	0	None	None	None	None
END_TIME	2330	2330	None	None	None	None
PLATFORM	GOES-7	GOES-7	None	None	None	None
INSTRUMENT	N/A	N/A	None	None	None	None
NUM_BANDS	3	3	None	None	None	None
BAND_QUALITY	N/A	N/A	None	None	None	None
CLOUD_COVER	N/A	N/A	None	None	None	None
NUM_VIS_IMAGES	0	48	None	None	None	None
NUM_IR_IMAGES	0	48	None	None	None	None
NUM_WV_IMAGES	0	24	None	None	None	None
CRTFCN_CODE	CPI	CPI	None	None	None	None

```
Minimum Data Value -- The minimum value found in the column.
Maximum Data Value -- The maximum value found in the column.
Missng Data Value  -- The value that indicates missing data. This is used to
                      indicate that an attempt was made to determine the
                      parameter value, but the attempt was unsuccessful.
Unrel Data Value   -- The value that indicates unreliable data.  This is used
                      to indicate an attempt was made to determine the
                      parameter value, but the value was deemed to be
                      unreliable by the analysis personnel.
Below Detect Limit -- The value that indicates parameter values below the
                      instruments detection limits.  This is used to
                      indicate that an attempt was made to determine the
                      parameter value, but the analysis personnel determined
                      that the parameter value was below the detection
                      limit of the instrumentation.
Data Not Cllctd    -- This value indicates that no attempt was made to
                      determine the parameter value.  This usually
                      indicates that BORIS combined several similar but
                      not identical data sets into the same data base table
                      but this particular science team did not
                      measure that parameter.
Blank -- Indicates that blank spaces are used to denote that type of value.
N/A   -- Indicates that the value is not applicable to the respective column.
None  -- Indicates that no values of that sort were found in the column.
```

7.4 Sample Data Record

A sample data record for the level-1 GOES-7 images is not available here. The following are wrapped versions of the first few records from the level-1 GOES-7 inventory table on the CD-ROM:

```
SPATIAL_COVERAGE,DATE_OBS,START_TIME,END_TIME,PLATFORM,INSTRUMENT,NUM_BANDS,
BAND_QUALITY,CLOUD_COVER,NUM_VIS_IMAGES,NUM_IR_IMAGES,NUM_WV_IMAGES,CRTFCN_CODE
'REGION',04-JAN-94,0,2330,'GOES-7','VISSR',3,'NOT ASSESSED','NOT ASSESSED',12,
12,6,'CPI'
'REGION',05-JAN-94,0,2330,'GOES-7','VISSR',3,'NOT ASSESSED','NOT ASSESSED',47,
48,24,'CPI'
```

8. Data Organization

8.1 Data Granularity

The smallest unit of data for level-1a GOES-7 image data is a single level-1a image. This includes extracted descriptive information in ASCII form; all visible, IR, and water vapor images collected within a given day of 0 to 2400 Greenwich Mean Time (GMT), and the reference latitude and longitude files for the images.

8.2 Data Format(s)

The CD-ROM inventory listing file consists of numerical and character fields of varying length separated by commas. The character fields are enclosed with single apostrophe marks. There are no spaces between the fields. One day of level-1a GOES-7 data is contained in four physical tape files:

- ASCII header file
- Visible image data file
- IR image data file
- Water vapor image data file

The reference latitude and longitude files for the visible, IR, and water vapor image data are appended as the last six files on the delivered tape.

The ASCII header file contains 80-byte ASCII records that describe the level-1a product; provide summary and detailed information about the good and zero-filled images for the given day; and contain descriptive header information extracted from the visible, IR, and water vapor images present.

One GOES-7 visible image contains 1,024 unsigned 6-bit counts (i.e., values from 0 to 63) stored in unsigned 8-bit (1-byte) values in each of 1,024 lines. A full day of visible image data consists of 48 half-hourly images. The visible image data file on tape contains a full day of visible image data. Each visible image data file on tape consists of 3,072 records of 16,384 bytes. Each tape record contains 16 visible image lines of 1,024 bytes (16,384 = 16 * 1024). Therefore, one visible image is contained in 64 tape records (64 = 1024/16). The sequence of image times in the file is 0000, 0030, 0100, 0130, ... 2300, 2330 GMT. If a given half-hourly visible image was not acquired, the level-1a product contains a set of 1,024 records containing 1,024 values of 0. The presence of these zero-filled images is shown in the ASCII header file. Placing these zero-filled images in the file for missing acquisitions keeps the images from the same time in the same physical location in each daily file.

One GOES-7 IR image contains 256 unsigned 8-bit counts (i.e., values from 0 to 255) stored in unsigned 8-bit (1-byte) values in each of 128 lines. A full day of IR image data consists of 48 half-hourly images. The IR image data file on tape contains a full day of IR image data. Each IR image data file on tape consists of 96 records of 16,384 bytes. Each tape record contains 64 IR image lines of 256 bytes (16,384 = 64 * 256). Therefore, one IR image is contained in two tape records. The sequence of image times in the file is 0000, 0030, 0100, 0130, ... 2300, 2330 GMT. If a given half-hourly IR image was not acquired, the level-1a product contains a set of 128 records containing 256 values of 0. The presence of these zero-filled images is shown in the ASCII header file. Placing these zero-filled images in the file for missing acquisitions keeps the images from the same time in the same physical location in each daily file.

One GOES-7 water vapor image contains 256 unsigned 8-bit counts (i.e., values from 0 to 255) stored in unsigned 8-bit (1-byte) values in each of 64 lines. A full day of water vapor image data consists of 24 hourly images. The water vapor image data file on tape contains a full day of water vapor image data. Each water vapor image data file on tape consists of 24 records of 16,384 bytes. Each tape record contains 64 water vapor image lines of 256 bytes (16,384 = 64 * 256). Therefore, one water vapor image is contained in one tape record. The sequence of image times in the file is 0000, 0100, 0200, ... 2300 GMT. If a given hourly water vapor image was not acquired, the level-1a product contains a set of 64 records containing 256 values of 0. The presence of these zero-filled images is shown in the ASCII header file. Placing these zero-filled images in the file for missing acquisitions keeps the images from the same time in the same physical location in each daily file.

The set of six reference latitude and longitude files for all the GOES-7 images collected in 1994 are appended as the last six files of the delivered tape. The six files consist of a pair of latitude and longitude files for each of the visible, IR, and water vapor image types.

The reference latitude and longitude files for the visible images each consist of 1,024 records of 4,096 bytes. Each record of 4,096 bytes contains 1,024 signed 32-bit (4-byte) integer latitude or longitude values. The bytes of each 32-bit value are stored as low-order byte first. The unit of each latitude and longitude value is thousandths of a degree. To get the original decimal degree values, divide each value by 1,000.

The reference latitude and longitude files for the IR images each consist of 128 records of 1,024 bytes. Each record of 1,024 bytes contains 256 signed 32-bit (4-byte) integer latitude or longitude values. The bytes of each 32-bit value are stored as low-order byte first. The unit of each latitude and longitude value is thousandths of a degree. To get the original decimal degree values, divide each value by 1,000.

The reference latitude and longitude files for the water vapor images each consist of 64 records of 1,024 bytes. Each record of 1,024 bytes contains 256 signed 32-bit (4-byte) integer latitude or longitude values. The bytes of each 32-bit value are stored as low-order byte first. The unit of each latitude and longitude value is thousandths of a degree. To get the original decimal degree values, divide each value by 1,000.

9. Data Manipulations

9.1 Formulae

9.1.1 Derivation Techniques and Algorithms

Using the BOREAS level-1 GOES-7 product as input, the data were processed to level-1a products. The processing included:

- Separating the header record and image data records contained in level-1 GOES image files
- Unpacking the header record information for use in processing control and output to the level-1a ASCII header file
- Filling missing images with zero-filled records
- Writing the four files for each day's data to disk
- Copying a 4-week period of daily files to tape
- Appending the reference latitude and longitude files to the tapes

9.2 Data Processing Sequence

9.2.1 Processing Steps

See Section 9.1.1.

9.2.2 Processing Changes

None.

9.3 Calculations
See Section 9.1.1.

9.3.1 Special Corrections/Adjustments
See Section 9.1.1.

9.3.2 Calculated Variables
See Section 9.1.1.

9.4 Graphs and Plots
None.

10. Errors

10.1 Sources of Error
The level-1a processing depended on the times provided in the level-1 GOES-7 image header records. If the time in the level-1 GOES-7 header record was incorrect, the image would have been placed in the incorrect sequence in the level-1a product. Any mixup between visible, IR, and water vapor images could not occur because file size checking was done during processing.

10.2 Quality Assessment

10.2.1 Data Validation by Source
Whatever the processing level, the geometric quality of the image depends on the accuracy of the viewing geometry. Spectral errors could arise because of image-wide signal-to-noise ratio, saturation, cross-talk, spikes, or response normalization caused by change in gain.

10.2.2 Confidence Level/Accuracy Judgment
Not available at this revision.

10.2.3 Measurement Error for Parameters
Not available at this revision.

10.2.4 Additional Quality Assessments
The level-1 GOES-7 images used to create the level-1a products were visually scanned for bad periods by FSU staff.

10.2.5 Data Verification by Data Center
See Section 9.1.1.

11. Notes

11.1 Limitations of the Data
Not available at this revision.

11.2 Known Problems with the Data
Occasional reception problems, especially during NOAA rapid-scan operations, may result in some images being truncated at the northern edge (top of image). When this occurs, visual review by FSU staff has ensured that the BOREAS areas of interest are still present.

11.3 Usage Guidance
None.

11.4 Other Relevant Information
None.

12. Application of the Data Set

These data were collected for the purpose of deriving surface radiation fields from the temporal series of images. The data can certainly be used for this purpose or other atmospheric and surface monitoring activities.

13. Future Modifications and Plans

None.

14. Software

14.1 Software Description
BORIS staff developed software and command procedures for:

- Extracting header information from level-1 GOES-7 images on tape and writing it to ASCII files on disk for initial quality checking
- Processing the files of level-1 GOES data for a given day to a level-1a product
- Writing the level-1a GOES image files from tape to disk
- Creating binary files of scaled latitude and longitude coordinates from the original ASCII files
- Appending the latitude and longitude files to tape

This software is written in C and is operational on VAX 6410, MicroVAX, and VAXstation systems at GSFC. The primary dependencies in the software are the tape I/O library and the Oracle data base utility routines.

14.2 Software Access
All of the described software is available upon request. BORIS staff would appreciate being informed of any problems discovered with the software, but cannot guarantee that they will be fixed.

15. Data Access

The level-1a GOES-7 visible, IR, and water vapor images are available from the Earth Observing System Data and Information System (EOSDIS) Oak Ridge National Laboratory (ORNL) Distributed Active Archive Center (DAAC).

15.1 Contact Information

For BOREAS data and documentation please contact:

ORNL DAAC User Services
Oak Ridge National Laboratory
P.O. Box 2008 MS-6407
Oak Ridge, TN 37831-6407
Phone: (423) 241-3952
Fax: (423) 574-4665
E-mail: ornldaac@ornl.gov or ornl@eos.nasa.gov

15.2 Data Center Identification

Earth Observing System Data and Information System (EOSDIS) Oak Ridge National Laboratory (ORNL) Distributed Active Archive Center (DAAC) for Biogeochemical Dynamics http://www-eosdis.ornl.gov/.

15.3 Procedures for Obtaining Data

Users may obtain data directly through the ORNL DAAC online search and order system [http://www-eosdis.ornl.gov/] and the anonymous FTP site [ftp://www-eosdis.ornl.gov/data/] or by contacting User Services by electronic mail, telephone, fax, letter, or personal visit using the contact information in Section 15.1.

15.4 Data Center Status/Plans

The ORNL DAAC is the primary source for BOREAS field measurement, image, GIS, and hardcopy data products. The BOREAS CD-ROM and data referenced or listed in inventories on the CD-ROM are available from the ORNL DAAC.

16. Output Products and Availability

16.1 Tape Products

The level-1a GOES-7 data can be made available on Digital Archive Tape (DAT) or 8-mm tapes.

16.2 Film Products

None.

16.3 Other Products

Although the image inventory is contained on the BOREAS CD-ROM set, the actual level-1a GOES-7 images are not. See Section 15 for information about how to obtain the data.

17. References

17.1 Platform/Sensor/Instrument/Data Processing Documentation

Rossow, W.B., C.L. Brest, and M. Roiter. 1996. International Satellite Cloud Climatology Project (ISCCP) New Radiance Calibrations. WMO/TD-No. 736. World Meteorological Organization.

Rossow, W.B., C.L. Brest, and M.D. Roiter. 1995. International Satellite Cloud Climatology Project (ISCCP): Update of radiance calibration report. Technical Document, World Climate Research Programme (ICSU and WMO), Geneva, Switzerland, 76 pp.

Rossow, W.B., Y. Desormeaux, C.L. Brest, and A. Walker. 1992. International Satellite Cloud Climatology Project (ISCCP): Radiance calibration report. WMO/Technical Document No. 520, World Climate Research Programme and World Meteorological Organization (ICSU and WMO), Geneva, Switzerland, 104 pp.

17.2 Journal Articles and Study Reports

Newcomer, J., D. Landis, S. Conrad, S. Curd, K. Huemmrich, D. Knapp, A. Morrell, J. Nickeson, A. Papagno, D. Rinker, R. Strub, T. Twine, F. Hall, and P. Sellers, eds. 2000. Collected Data of The Boreal Ecosystem-Atmosphere Study. NASA. CD-ROM.

Sellers, P. and F. Hall. 1994. Boreal Ecosystem-Atmosphere Study: Experiment Plan. Version 1994-3.0, NASA BOREAS Report (EXPLAN 94).

Sellers, P. and F. Hall. 1996. Boreal Ecosystem-Atmosphere Study: Experiment Plan. Version 1996-2.0, NASA BOREAS Report (EXPLAN 96).

Sellers, P., F. Hall, and K.F. Huemmrich. 1996. Boreal Ecosystem-Atmosphere Study: 1994 Operations. NASA BOREAS Report (OPS DOC 94).

Sellers, P., F. Hall, and K.F. Huemmrich. 1997. Boreal Ecosystem-Atmosphere Study: 1996 Operations. NASA BOREAS Report (OPS DOC 96).

Sellers, P., F. Hall, H. Margolis, B. Kelly, D. Baldocchi, G. den Hartog, J. Cihlar, M.G. Ryan, B. Goodison, P. Crill, K.J. Ranson, D. Lettenmaier, and D.E. Wickland. 1995. The boreal ecosystem-atmosphere study (BOREAS): an overview and early results from the 1994 field year. Bulletin of the American Meteorological Society. 76(9):1549-1577.

Sellers, P.J., F.G. Hall, R.D. Kelly, A. Black, D. Baldocchi, J. Berry, M. Ryan, K.J. Ranson, P.M. Crill, D.P. Lettenmaier, H. Margolis, J. Cihlar, J. Newcomer, D. Fitzjarrald, P.G. Jarvis, S.T. Gower, D. Halliwell, D. Williams, B. Goodison, D.E. Wickland, and F.E. Guertin. 1997. BOREAS in 1997: Experiment Overview, Scientific Results and Future Directions. Journal of Geophysical Research 102 (D24): 28,731-28,770.

17.3 Archive/DBMS Usage Documentation

None.

18. Glossary of Terms

None.

19. List of Acronyms

ASCII	- American Standard Code for Information Interchange
ATS	- Application Technology Satellite
BOREAS	- BOReal Ecosystem-Atmosphere Study
BORIS	- BOREAS Information System
BPI	- Bytes Per Inch
CCT	- Computer Compatible Tape
CD-ROM	- Compact Disk-Read-Only Memory
DAAC	- Distributed Active Archive Center
DAT	- Digital Archive Tape
DN	- Digital Number

EOS - Earth Observing System
EOSDIS - EOS Data and Information System
ESD - Environmental Satellite Data, Inc.
FFC - Focused Field Campaign
FOV - Field of View
GIS - Geographic Information System
GMT - Greenwich Mean Time
GOES - Geostationary Operational Environmental Satellite
GSFC - Goddard Space Flight Center
IFC - Intensive Field Campaign
IFOV - Instantaneous Field-of-View
IR - Infrared
ISLSCP - International Satellite Land Surface Climatology Project
MB - Megabyte
MSI - Multispectral Imaging
NAD83 - North American Datum of 1983
NASA - National Aeronautics and Space Administration
NESDIS - National Environmental Satellite, Data and Information Service
NOAA - National Oceanic and Atmospheric Administration
NSA - Northern Study Area
ORNL - Oak Ridge National Laboratory
PANP - Prince Albert National Park
RSS - Remote Sensing Science
SBRS - Santa Barbara Remote Sensing
SDB - Synchronous Data Buffer
SMS - Synchronous Meteorological Satellite
SSA - Southern Study Area
URL - Uniform Resource Locator
VAS - VISSR Atmospheric Sounder
VISSR - Visible and IR Spin Scan Radiometer

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When using these data, please include the following acknowledgment as well as citations of relevant papers in Section 17.2: The level-1a GOES-7 images resulted from a joint effort between BOREAS staff at NASA GSFC and Dr. Eric Smith of FSU. The original data were acquired by FSU and processed to level-1 products. The present level-1a product was created by BORIS staff. The respective contributions of the above individuals and agencies to completing this data set are greatly appreciated.

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13. ABSTRACT *(Maximum 200 words)*

The BOREAS RSS-14 team collected and processed GOES-7 and -8 images of the BOREAS region as part of its effort to characterize the incoming, reflected, and emitted radiation at regional scales. The level-1a BOREAS GOES-7 image data were collected by RSS-14 personnel at FSU and processed to level-1a products by BORIS personnel. The data cover the period of 01-Jan-1994 through 08-Jul-1995 with partial to complete coverage on the majority of the days. The data include three bands with eight-bit pixel values. No major problems with the data have been identified.

Note: due to the large size of the images, the level-1a GOES-7 data are not contained on the BOREAS CD-ROM set. An inventory listing file is supplied on the CD-ROM to inform users of what data were collected. The level-1a GOES-7 image data are available from the Earth Observing System Data and Information System (EOSDIS) Oak Ridge National Laboratory (ORNL) Distributed Active Archive Center (DAAC). See sections 15 and 16 for more information.

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